NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO ATTN OF: GP

October 16, 1970

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,324,659

Corporate Source : Lewis Research Center

Supplementary Corporate Source :

NASA Patent Case No.: XLE-01902

Gayle Parker

Enclosure:
Copy of Patent

N71-10574
(ACCESSION NUMBER) (THRU)
4 (PAGES) 00 (CODE)
(NASA CR OR TMX OR AD NUMBER) 28 (CATEGORY)

FACILITY FORM 602

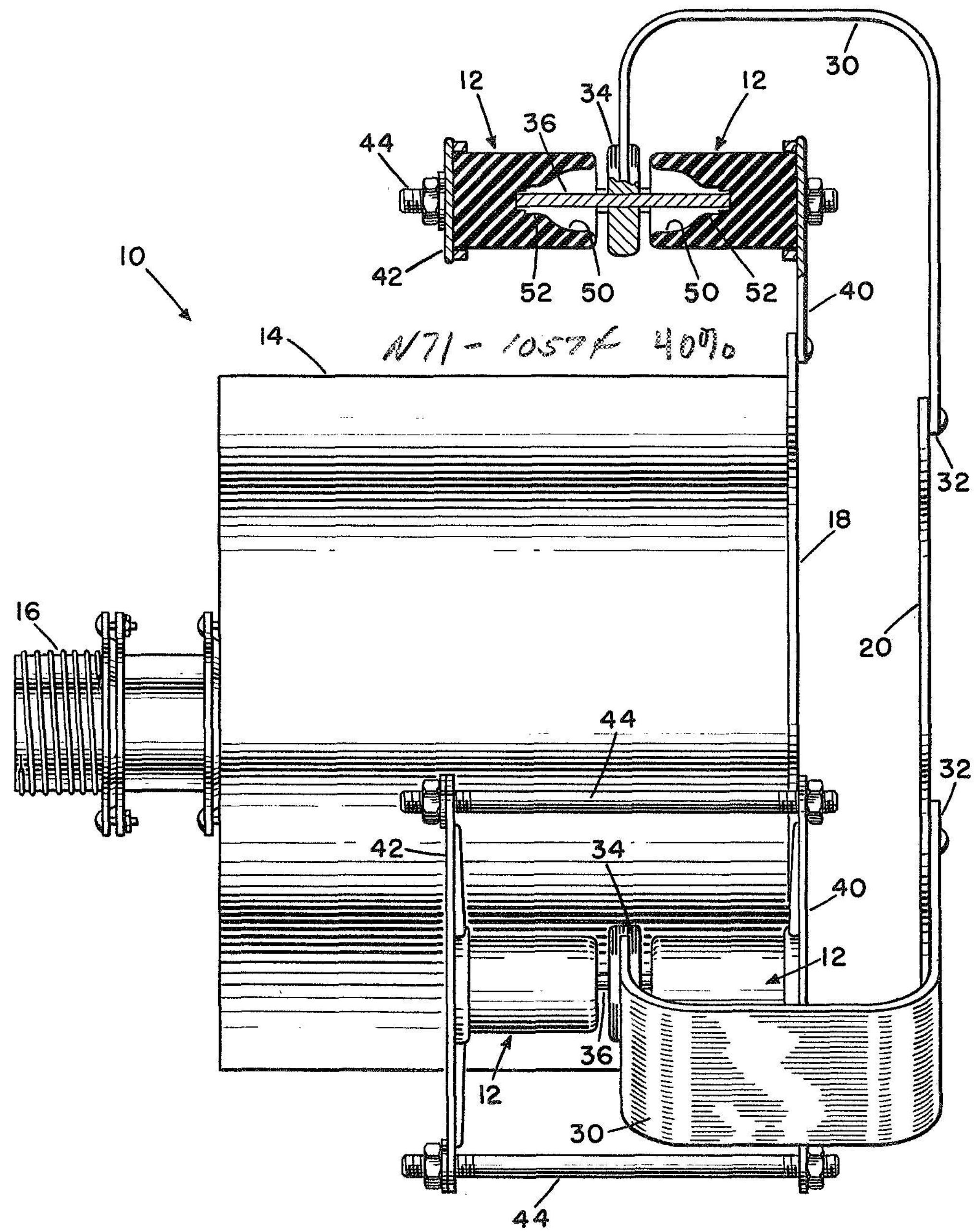
NASA-HQ

N71-10574

June 13, 1967 D. C. BYERS ET AL 3,324,659

ELECTROSTATIC THRUSTOR WITH IMPROVED INSULATORS

Filed Sept. 7, 1965



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United States Patent Office 3,324,659
Patented June 13, 1967

3,324,659
ELECTROSTATIC THRUSTOR WITH IMPROVED INSULATORS

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Filed Sept. 7, 1965, Ser. No. 485,656
7 Claims. (Cl. 60—202)

ABSTRACT OF THE DISCLOSURE

High voltage insulators for direct current in a vacuum environment. Electrons released by field emission are constrained in the region of the negative junction to eliminate surface flashover and unstable operation. The insulators are particularly useful in the acceleration system of an electrostatic thrustor.

The invention described herein may be manufactured and used by and for the Government of the United States of America for governmental purposes without the payments of any royalties thereon or therefor.

This invention is concerned with an improvement in high voltage insulation in a vacuum and, more particularly, with insulators for an electrostatic thrustor. The invention is primarily directed to improved insulators for use in the acceleration system of an electron bombardment ion thrustor.

High voltage direct current insulation in a vacuum environment has been a problem in the field of electrostatic thrustors. Spherical insulators of the type described in U.S. Patent No. 3,156,090 do not withstand the voltage required for the operation of high impulse thrustors which may utilize up to 100,000 volts in their acceleration systems. It has been found that a spherical insulator having a diameter of two inches usually breaks down at about 22,000 volts.

A proposed solution to this problem has been to increase the size of the spherical insulators. Such an expedient is undesirable in space applications where an electrostatic thrustor is used because of weight restriction.

This insulation problem arises because electrical breakdown across an insulator usually commences in a vacuum with electrons drawn from the negative electrode striking the positive electrode and knocking out more electrons. This "cascade" or "avalanche" process is the most widely held theory of vacuum breakdown.

With the spherical insulators of the type shown in the aforementioned U.S. patent, high stress fields are prevalent at the points of contact between the spheres and the planes or spaced electrodes because of the small area of contact. In such installations where strong electric fields are prevalent, as in the case of an electrostatic thrustor, a strong electric field at a point on the negative electrode will extract electrons by field emission.

The problems arising from the use of conventional insulators for electrostatic thrustors have been solved by utilizing insulators constructed in accordance with the present invention. Because the electrostatic field is directed through the dielectric material of these insulators, electrons emitted by field emission are constrained in the region of the negative junction. Also, there is probably some reduction in the electric field strength at the negative junction. In this manner, surface flashover and unstable operation at high voltages have been eliminated, and the maximum voltage the insulators of the invention can support is limited only by the dielectric strength of the insulator material.

It is, therefore, an object of the present invention to provide an improved high voltage insulator for use in a vacuum environment.

Another object of the present invention is to provide an improved insulator for an electrostatic ion thrustor.

These and other objects of the invention will be apparent from the specification which follows and the drawings wherein like numerals are used throughout to identify like parts.

The drawing is a view in elevation with parts in section of an electrostatic thrustor having an acceleration system which utilizes insulators constructed in accordance with the present invention.

Referring now to the drawing there is shown an electrostatic thrustor **10** having an acceleration system which utilizes insulators **12** constructed in accordance with the present invention. The thrustor **10** includes a cylindrical casing **14**, the center of which forms an ion chamber. A propellant source **16** is located at the forward end of the thrustor **10** and is in communication with the ion chamber within the casing **14**. This propellant source may be in the form of a steam jacketed boiler of the type shown in Patent No. 3,156,090 having a calibrated orifice at the entrance to the ion chamber.

Neutral particles in the form of a gaseous propellant, such as mercury, enter the upstream end of the ion chamber in which high velocity electrons thermionically emitted by a cathode in the form of a hot filament in the chamber ionize these particles to form a plasma. A screen grid **18** and an accelerator grid **20** at the downstream end of the ion chamber comprise the accelerator system of the thrustor. This accelerator system serves to focus and accelerate ions that reach the downstream end of the thrustor. The thrust producing mechanism of this device is the momentum change of the ions as they are accelerated by an electrostatic field which is applied between the screen and accelerator grids.

Both the screen grid **18** and accelerator grid **20** are connected to suitable sources of power in the manner shown in the aforementioned Patent No. 3,156,090. The screen grid **18** is maintained at the voltage potential substantially equal to that of the thermionically emitting cathode within the ion chamber while the accelerator grid **20** has relatively high negative potential relative to the screen grid.

The accelerator grid **20** is mounted on the screen grid **18** by brackets **30** which serve to maintain the proper spacing between these two grids, as shown in the drawing. Each bracket **30** has a J-shaped configuration and is secured at one end **32** to the accelerator grid **20**. Each bracket **30** curves toward the forward end of the thrustor **10** and has a head **34** mounted on the opposite end. A pin **36** extends through the head **34** and is substantially parallel with the axis of the thrustor **10**.

The screen grid **18** carries spaced arms **40** which extend radially outward therefrom. A plate **42** is mounted on each of the arms **40** by spaced bolts **44**.

The insulators **12**, which are constructed in accordance with the present invention, are mounted between the arms **40** and the plates **42** as shown in the drawing. Each insulator **12** is of a dielectric material, such as aluminum oxide, and has a substantially flat face which engages either the arm **40** or the plate **42**.

At the opposite end is the recessed portion **50** which receives the pin **36** shown in the drawing. It has been found that the pin **36** should extend into the recessed portion of the insulator **12** a distance greater than the width of the opening of the recessed portion.

As shown in the drawing, the recessed portion **50** is provided with a cylindrical depression **52** at the bottom thereof. This depression serves to decrease the local electric field strength at the junction between the pin **36** and

the insulator **12**. It has been found that the ratio of the penetration of the pin **36** in the depression **52** to the gap between the pin **36** and the surface of the depression **52** should be about 4 to 1. While further penetration of the pin **36** into the depression **52** provides some improvement in performance, this improvement is slight when the aforementioned ratio is exceeded.

The accelerator grid **20**, as well as the bracket **30** with the pin **36** connected thereto, is highly negative relative to the screen grid **18** and the arms **40** as previously explained. Consequently, each pin **36** constitutes a negative electrode. The recessed portion **52** of each insulator **12** serves to shield this negative electrode to prevent electrical breakdown at high voltages.

While the preferred embodiment of the invention has been shown and described, it will be appreciated that various structural modifications can be made to the insulator as well as the electrostatic thrustor without departing from the spirit of the invention or the scope of the subjoined claims. For example, it is contemplated that insulators constructed in accordance with the invention could be utilized for high voltage AC vacuum applications by mounting the insulators in a back-to-back fashion.

What is claimed is:

1. In an electrostatic ion thrustor of the type having a casing forming an ion chamber with a screen grid adjacent one end thereof and an accelerator grid spaced therefrom having a high negative DC potential relative to the screen grid and casing to accelerate ions away from the thrustor in a vacuum environment, the improvement comprising

- a plurality of insulators for electrically insulating the accelerator grid from the casing and screen grid, each of said insulators having a recessed portion,
- a plurality of elongated members rigidly mounted on the accelerator grid, each of said elongated members having the same high negative potential relative to the screen grid thereby forming a negative electrode, and
- means for rigidly mounting said insulators on the casing adjacent said elongated members with the openings of the recessed portions facing said elongated members for receiving the same and shielding the ends thereof to prevent electrical breakdown at high voltages.

2. Apparatus as claimed in claim **1** wherein the elongated members extend into the recessed portion of the insulator a distance greater than the width of the opening of the recessed portion.

3. Apparatus as claimed in claim **1** wherein the insulator has a depression at the end of the recessed portion remote from the opening thereof for contacting the outermost end of the elongated members.

4. Apparatus as claimed in claim **3** wherein the width of the depression is greater than that of the elongated members to form a gap between the surfaces of the depression and elongated members.

5. Apparatus as claimed in claim **4** where the ratio penetration of the elongated members into the depression to the gap is about 4 to 1.

6. An acceleration system for an electrostatic ion thrustor of the type having a casing forming an ion chamber comprising

- a screen grid mounted on the casing at one end of the ion chamber and having the same potential as the casing,
- a plurality of spaced arms carried by said screen grid and extending radially outward from the casing,
- a plate mounted on each of said arms and spaced therefrom,
- an accelerator grid spaced from said screen grid and having a high negative potential relative to the casing,
- a plurality of brackets, each having one end secured to said accelerator grid and another end positioned in the space between one of said arms and the plate mounted thereon,
- a pin mounted on said other end of each of said brackets in said space, said pin having one end facing said one of said arms and another end facing said plate,
- a first insulator having a flat surface in engagement with said one of said arms and a concave surface adjacent said one end of said pin, and
- a second insulator having a flat surface in engagement with said plate mounted on said one of said arms and a concave surface adjacent said other end of said pin.

7. An accelerator system for an ion thrustor as claimed in claim **6** including

- a depression in the first insulator for receiving the one end of the pin, and
- a depression in the second insulator for receiving the other end of the pin.

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